Implantable, Rechargeable Microbatteries for BION™ Microstimulators

Opportunity

Microstimulators powered by long-lived, rechargeable lithium-ion batteries could offer hope for victims of stroke, Parkinson's disease, epilepsy, urinary urge incontinence, eyelid droop, and similar conditions involving muscular impairment. An estimated 7 million Americans suffer from conditions that could benefit from treatment with muscle microstimulators.

Muscle function could be restored in such patients by using tiny, programmable electronic implants called BIONs™ (Figure 1). By stimulating muscles or their associated nerves, BIONs prevent muscles from deteriorating and may help restore mobility. Limited clinical testing has begun, with promising results.

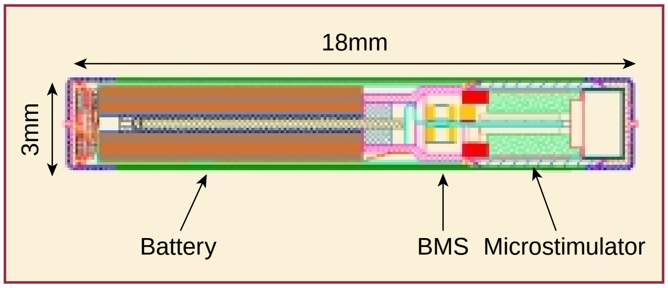

Figure 1. Prototype battery-powered BION implant. The BION technology was developed by Advanced Bionic. The device consists of a miniature rechargeable battery; a battery management system (BMS), which is responsible for remote reprogramming and recharging of the battery; and an advanced microstimulator.

Technology Need

The partners in the BION venture seek a micro-miniature, rechargeable, and inherently safe lithium battery that will last 10 years. No existing lithium battery technology meets these requirements. The lithium batteries currently used in many implantable medical devices are too big, cannot be recharged, and last only 3 years at most. Size is a particular challenge (Figure 2), because the implants are only 18 millimeters long and 3 millimeters in diameter, and about one-third of that volume is required for the stimulator mechanism.

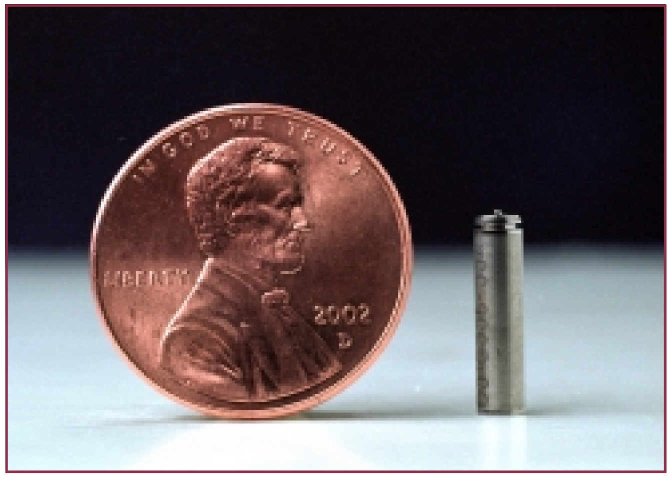

Figure 2. Photograph of a prototype developed by Quallion, LLC showing the scale of the miniature battery required for BIONs.

Argonne Approach

For this application, Argonne is developing an entirely new lithium battery chemistry, featuring a silicon-based polymer electrolyte, siloxane. Until now, this lithium-ion-conducting polymer has not been considered for batteries. The new electrolyte is attractive for the BION implants because it is

- Highly conductive at body temperature (permitting smaller size),
- Nontoxic to humans,
- Chemically stable,
- Nonvolatile, and
- Nonflammable.

In addition to helping patients, successful development of this battery chemistry could revolutionize the lithium battery market for consumer electronics, because it is projected to cost less than current technologies.

Accomplishments

Argonne has fabricated a thin film (Figure 3) in which siloxane, a liquid polymer, is crosslinked in the pores of a porous substrate — a prerequisite for commercial production. At body temperature (and room temperature), the conductivity of this film is similar to that of the flammable and volatile organic electrolyte used in commercial lithium-ion batteries.

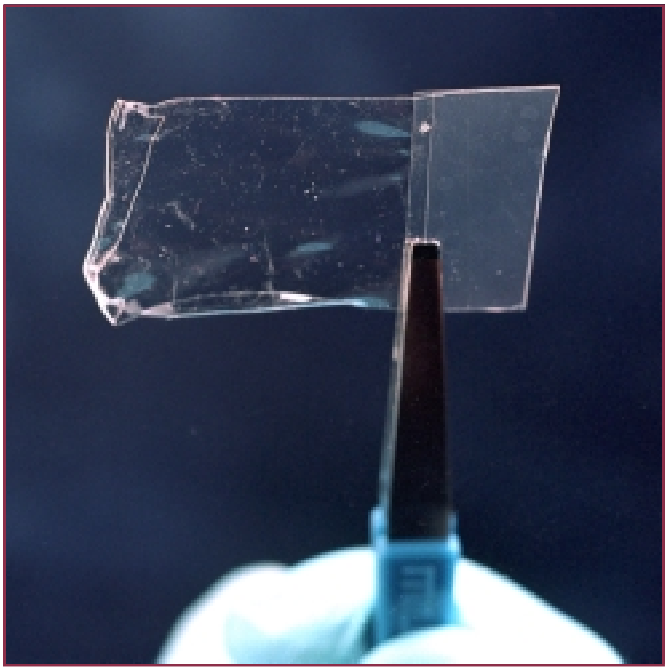

Figure 3. Argonne has demonstrated that, by using a second polymer to form a host network, the silicon-based liquid polymer electrolyte (siloxane) can be crosslinked in a solid thin film. The liquid siloxane electrolyte was initially developed at the University of Wisconsin.

Small prototype cells made with this siloxane film have been tested by repeated charging and discharging (cycling). The cells maintained their charge capacity (Figure 4), and the electrolyte remained chemically stable even in the presence of reactive (oxidizing) electrode materials.

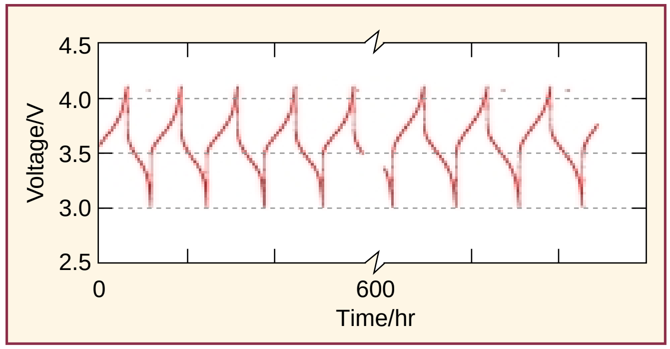

Figure 4. A siloxane solid polymer electrolyte formulated at Argonne shows stable performance over many charge/discharge cycles.

Future Work

Continuing research and development at Argonne will focus on the following tasks:

- Optimize liquid siloxane polymers to obtain even higher lithium ion conductivity,
- Develop thin-film processing techniques that retain the conductivity of the liquid siloxane, and
- Develop electrode materials that are compatible with the new siloxane polymer electrolyte.

Other partners are focusing on cell integration and packaging, a recharging system, and microelectronic control systems that will allow multiple implants to work together as an intelligent microstimulation array.

Partners

Alfred E. Mann Foundation
Quallion, LLC
Lithchem International
Valtronic
University of Wisconsin, Organosilicon Research Center

Sponsor

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